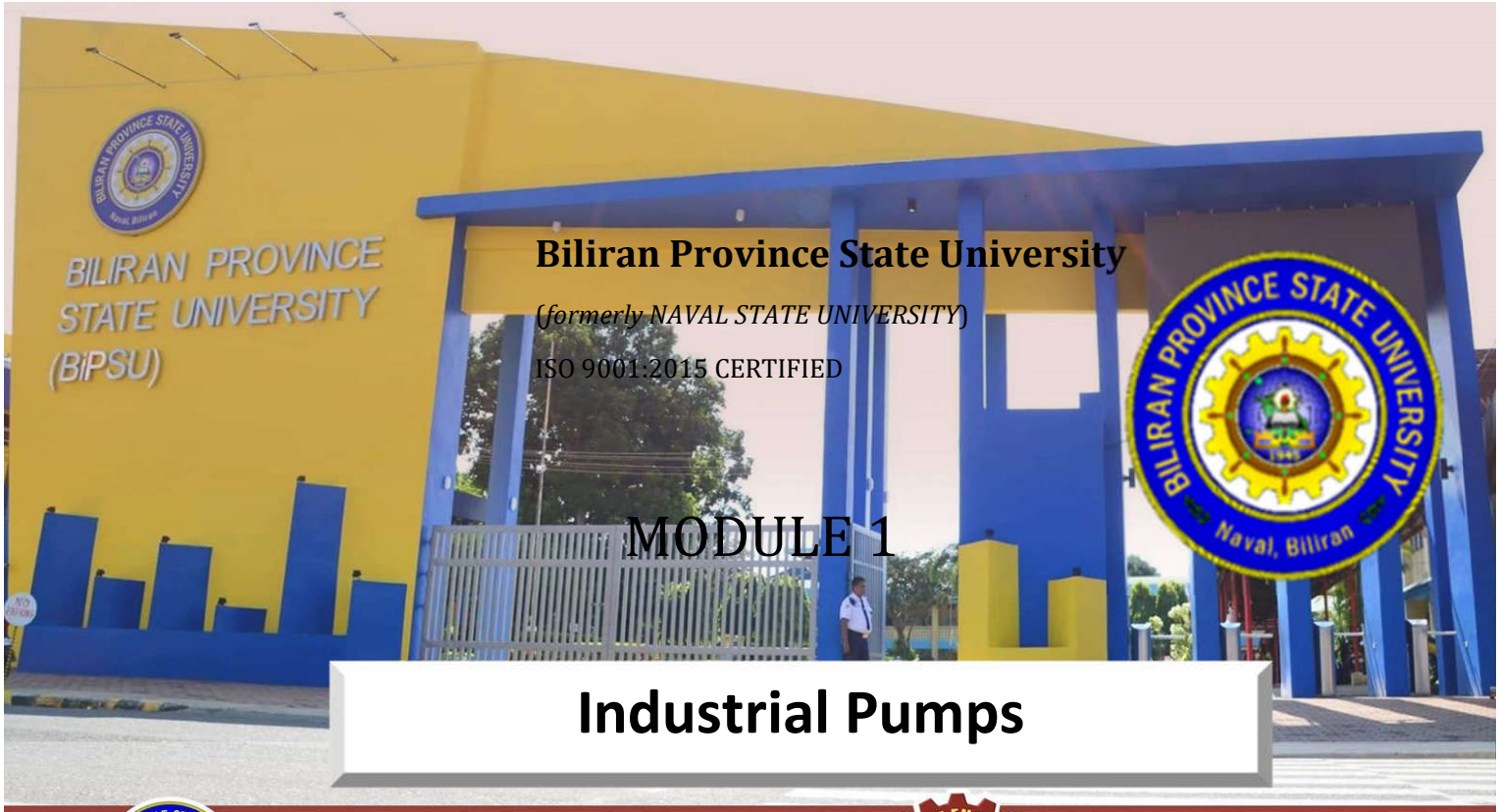

Biliran Province State University

(formerly NAVAL STATE UNIVERSITY)

ISO 9001:2015 CERTIFIED

MODULE 1

Industrial Pumps

BILIRAN PROVINCE STATE UNIVERSITY | SCHOOL OF ENGINEERING

Industrial Processes

MECHANICAL ENGINEERING

First Semester, SY 2020-2021

Course Code	:	ME 213
Course Title	:	Thermodynamics 1
Pre-requisite	:	Phys 123 & Phys 121L & Math 123 & Chem 113 and Chem 113L
Co-Requisite	:	None
Credit Units	:	3 units
Time Allotment	:	3 hours/week, 54 hours/semester
For this module	:	2 weeks only

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To my ruler and controller in my life, thank you so much God for always guiding me to the right path of my daily life.

To my family, thank you for the moral support. I always acknowledge all of your efforts to make me comfortable in all my decisions.

RLPJR

PLEASE TELL YOUR SUGGESTIONS/COMMENTS

Communications are welcome from students, readers and professors especially for your concerning errors and comments for the improvement of this material. I spent more time in making this module yet, I believed that you will be part for the future enhancement of this module. Your comments will be highly appreciated. Please email to pitaoramonjr@gmail.com or rpitao@bipsu.edu.ph. Thank you…….

Purpose of the Learning Module

- The purpose of this learning module is to introduce the basic theory of pumps for the field of engineering applications.
- To assess the learning outcomes of the students using this learning module.

Learning outcomes

- The students could be able to solve, estimate and hydraulic analysis of pumps for their specific applications.

Learning guide

- Read and understand every topic of this module. It is important to understand the principles behind of each topic of this module since it is be useful for the next topic for this course.
- Focus on the different applications of pumps and its corresponding equations for the purpose of later actual applications.
- This module is good for two weeks' time only so manage your time properly.
- Perform the pre-assessment test below and follow the instruction accordingly.
- At the end part of the module, perform the post-assessment with proper solution and knowledgeable way as your learning outcomes. Take note that your rating of this post-assessment test is recorded as your grade performance.
- As the summary of your learning outcome you will be task one presentation using Microsoft PowerPoint containing all the topic discuss in this module. You can go to the task summary or culminating activity at the last part of this module for the complete details.
- Lastly, don't forget to right your thoughts, comments and suggestions on the feedback section of this module. Your comments will be part of the enhancement for the next revision of this instructional material.

Pre-assessment test

Let's try your knowledge on thermodynamics. Write your answers on the space

Provided.

1. A fuel pump is delivering 10 gallons per minute of oil with a specific gravity of 0.83. The total head is 9.14 m, find how much energy does the pump consumes in kJ per hour.

2. A pump receives 8 kg/s of water at 220 kPa and 110 degree C and discharges it at 1100 kPa. Compute the power required in kW.

3. A pump lifts water at a rate of 283 liters per second from a lake and force it into a tank 8 m above the level of the water at a pressure of 137 kPa. What is the power required in kW?

4. A pump discharges 150 liters per second of water to a height of 75 m. If the efficiency is 75% and the speed of the pump is 1800 rpm, what is the torque in N-m to which the drive shaft is subjected?

5. A centrifugal pump delivers 80 liters per second of water on test suction gauge reads 10 mm Hg vacuum and 1.2 m below pump centerline. Power input is 70 kW. Find the total dynamic head in meters.

6. A pump with a 400 mm diameter suction pipe and a 350 mm diameter discharge pipe is to deliver 20,000 liters per minute of 15.6 degree C water. Calculate the pump head in meters if suction gage is 7.5 cm below pump centerline and reads 127 mm Hg vacuum and discharges gage is 45 cm above the pump centerline and reads 75 kPa.

7. A centrifugal pump delivers 300,000 liters per hour of water to a pressurized tank whose pressure is 284 kPa. The source of water is 5 m below the pump. The diameter of the suction pipe is 300 mm and the discharge pipe is 250 mm. Calculate the kW rating of the driving motor assuming the pump efficiency to be 72%.

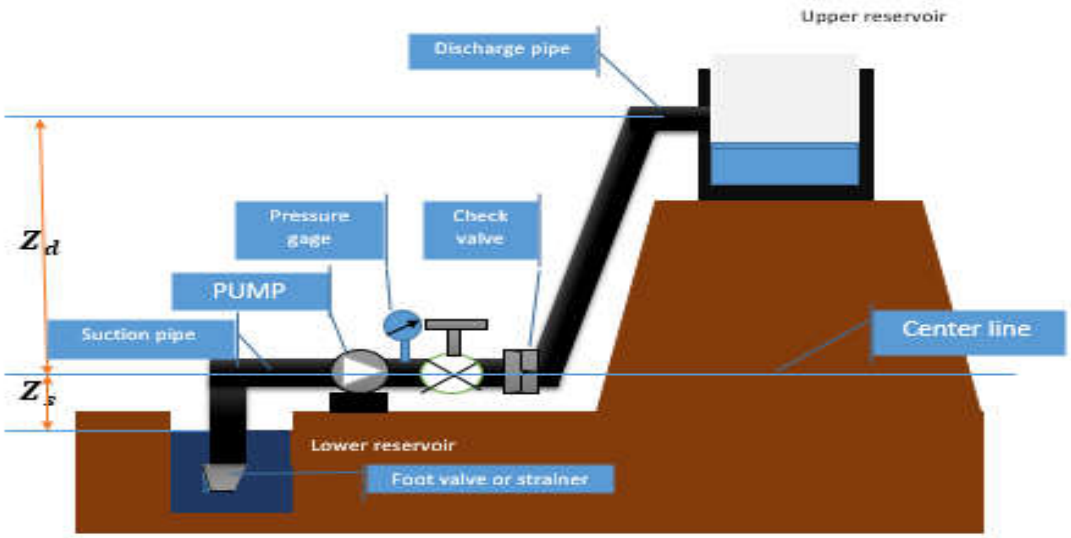
8. A pumps delivers 500 gpm of water against a total head of 200 ft and operating at 1770 rpm. Changes have increased the total head to 375 ft. At what rpm should the pump be operated to achieve the new head at the same efficiency?

9. The rate of flow of water in a pump installation is 60.6 kg/s. The intake static gage is 1.22 m below the pump centerline and reads 68.95 kPa gage: the discharge static gage is 0.61 m below the pump centerline and reads 344.75 kPa gage. The gases are located close to the pump as much as possible. The area of the intake and discharge pipes are 0.093 m^2 and 0.069 m^2 respectively. The pump efficiency is 74%. Take density of water equals 1000 kg/m^3. What is the hydraulic power in kW?

10. It is desired to deliver 5 gpm at a head of 640 ft in a single stage pump having a specific speed not to exceed 40. If the speed is not to exceed 1352 rpm, how many stage are required?

I. PUMPS

A machine which is used to add energy to a liquid in order to transfer the liquid from one point to another point of higher energy level.



General formulas:

$discharge = Q = Av$

$P = \gamma Z$

$velocity\ head = v = \sqrt{2gh_v}$

$$total\ dynamic\ head = H = (Z_d - Z_s) + \frac{P_d + P_s}{\gamma} + (h_{fs} + h_{fd}) + \frac{V_d^2 - V_s^2}{2g}$$

$water\ power = Q\gamma H$

$$break\ power = \frac{Q\gamma H}{e_{pump}}$$

Pumps in Parallel

$Q = Q_1 + Q_2$

$H = H_1 = H_2$

$P = P_1 + P_2$

Pumps in Series

$Q = Q_1 = Q_2$

$H = H_1 + H_2$

$P = P_1 + P_2$

Sample problem 1

Water is pumped at the rate of 1400 gpm through a centrifugal pump operating at a speed of 1750 rpm. The impeller has a uniform blade length, b, of 2 in. with r_1 = 1.9 in. and r_2 = 7.0 in., and the exit blade angle is β=23º . Assume ideal flow conditions and that the tangential velocity component, $V_{\theta 1}$, of the water entering the blade is zero (α_1=90 º). Determine the power, W_{shaft}transferred to the fluid.

Solution

The tip velocity of the impeller

$U_2 = \omega r_2 = (7/12ft)(2\pi rad/rev)(1750rpm/60s/min) = 107ft/s$

Since the flowrate is given

$Q = 2\pi r_2 b_2 Vr_2 \qquad Vr_2 = \frac{Q}{2\pi r2 b2} = 5.11ft/s$

$\cot\beta_2 = \frac{U^2 - V_{\theta 2}}{Vr_2}$

$V_{\theta 2} = U^2 - Vr_2 \cot\beta_2 = 95.0ft/s$

$h_i = \frac{U^2 V_{\theta 2}}{g} = 316ft$

$W_{shaft} = \rho Q U_2 V_{\theta 2} = \ldots =$ **112hp**

Sample problem 2

A centrifugal pump requires 40ft head to deliver water from low level to higher level. If pump speed is 1600rpm, determine the impeller diameter of the centrifugal pump.

Solution:

$$v = \sqrt{2gh} = \sqrt{2(9.81)\left(\frac{40}{3.281}\right)} = 15.466\,\frac{m}{sec}$$

$$v = \pi DN$$

$$15.466 = \pi D\left(\frac{1600}{60}\right)$$

$$\boldsymbol{D = 0.18461m = 184.61mm}$$

Sample problem 3

A pump is to deliver 150gpm of water at a head of 120m. if pump efficiency is 70%, what is the horsepower rating of motor required to drive the pump?

Solution:

$$W_p = wQh$$

$$W_p = 9.81\left(\frac{150x0.003785}{60}\right)(120) = 11.139\ kW$$

$$BP = \frac{11.139}{0.7} = \boldsymbol{15.913kW = 21.33hp}$$

Sample problem 4

The discharge pipe of a pump is 400mm in diameter 0.5 cubic meter per second of water ta a building which maintain a pressure of 100kPa at a height of 30m above the reservoir. If equivalent head is 2m, what power must be furnished by the pump?

Solution:

$$Q = Av$$

$$0.5 = \left(\frac{\pi}{4}0.4^2\right)v$$

$$v = 3.9788\,\frac{m}{sec}$$

$$h = \frac{v^2}{2g} + \frac{P}{w} + z$$

$$h = \frac{3.9788^2}{2x9.81} + \frac{100}{9.81} + (30 + 2)$$

$$h = 43m$$

$$W_p = wQh = 9.81x0.50x43 = \mathbf{210.92}\boldsymbol{kW}$$

Sample problem 5

The elevation of suction reservoir is 5m above the pump centerline and delivers to 85m elevation tank which maintain 150kPa. If 1.5 cubic meter per second of water is used to deliver a total head of 3m, determine the power needed by the pump.

Solution:

$$h = (85 - 5) + 3 + \frac{150}{9.81}$$

$$h = 98.29m$$

$$P = wQh = 9.81x1.5x98.29 = \mathbf{1446.34}\boldsymbol{kW}$$

Post Test

Solve the following problems by applying proper and correct diagram, solutions, terminologies, principles, formula and theory related to pumps on the space being provide. Put always a box that indicate your final answer.

1. A pump with a 400 mm diameter suction pipe and a 350 mm diameter discharge pipe is to deliver 20,000 liters per minute of 15.6 degree C water. Calculate the pump head in meters if suction gage is 7.5 cm below pump centerline and reads 127 mm Hg vacuum and discharges gage is 45 cm above the pump centerline and reads 75 kPa.

   Solution:

2. A centrifugal pump delivers 300,000 liters per hour of water to a pressurized tank whose pressure is 284 kPa. The source of water is 5 m below the pump. The diameter of the suction pipe is 300 mm and the discharge pipe is 250 mm. Calculate the kW rating of the driving motor assuming the pump efficiency to be 72%.

   Solution:

3. A pumps delivers 500 gpm of water against a total head of 200 ft and operating at 1770 rpm. Changes have increased the total head to 375 ft. At what rpm should the pump be operated to achieve the new head at the same efficiency?

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4. The rate of flow of water in a pump installation is 60.6 kg/s. The intake static gage is 1.22 m below the pump centerline and reads 68.95 kPa gage: the discharge static gage is 0.61 m below the pump centerline and reads 344.75 kPa gage. The gases are located close to the pump as much as possible. The area of

the intake and discharge pipes are 0.093 m^2 and 0.069 m^2 respectively. The pump efficiency is 74%. Take density of water equals 1000 kg/m^3. What is the hydraulic power in kW?

Solution:

5. It is desired to deliver 5 gpm at a head of 640 ft in a single stage pump having a specific speed not to exceed 40. If the speed is not to exceed 1352 rpm, how many stage are required?

Solution:

6. The power output is 30 Hp to a centrifugal pump that is discharging 900 gpm and which operates at 1800 rpm against a head H=120 ft, 220 V, 3 phase, 60 hertz. If this pump is modified to operate 1200 rpm, assuming its efficiency remain constant, determine its discharge in gpm, the theoretical head imparts to the liquid and the power input to the pump.

Solution:

7. A pump operating at 1750 rpm delivering 500 gal/min against a total head of 150 ft. Changes in the piping system have increased the total head to 360 ft. At what rpm should the pump be operated to achieve this new head at the same efficiency?

Solution:

8. Water in the rural areas is often extracted from underground water source whose free surface is 60 m below ground level. The water is to be raised 5 m above the ground by a pump. The diameter of the pipe is 10 cm at the inlet and 15 cm at the exit. Neglecting any heat interaction with the surroundings and frictional heating effects. What is the necessary power input to the pump in kW for a steady flow of water at the rate of 15 li/s? Assume pump efficiency of 74%.

Solution:

9. Find the hydraulic power and the mechanical efficiency of rotary pump direct connected to a 5 Hp electrical motor operating at full load under the following conditions:
Fluid handled oil, temperature 21 deg. C, specific gravity 0.85, volume flow rate 20 li/s, total head 175 kPa.

Solution:

10. Water from an open reservoir A at 8 m elevation is drawn by a motor driven pump to an open reservoir B at 70 m elevation. The inside diameter of the suction pipe is 200 mm and 150 mm for the discharge pipe. The suction line has a loss of head three times that of the velocity head in the 200 mm pipe. The discharge line has a loss of head twenty times that of the velocity head in the discharge pipeline. The pump centerline is at 4 m. Overall efficiency of the system is 78%. For a discharge rate of 10 li/s, find the power input to the motor and the pressure gage readings installed just at the outlet and the inlet of the pump in kPag.

Solution:

Culminating Activity

1. Prepared a presentable slides containing sample discussions about the application of different pump applications. Record your discussion using clear camera and audio and limit your discussion up to 15 minutes only. Burn the output file into the compact disc CD or Digital Optical Disc DVD and submit this output after the semester. Note! All formulas and solution must be encoded.
2. Make a portfolio for heat different pumps applications. The portfolio must contains a minimum of twenty (20) items problems with solutions that is related to pumps and it must be encoded (electronics copy) both solutions and problems.

Write your feedback here

References

1. Power and Industrial Plant Engineering second edition by JAS Tordillo
2. Industrial Plant Engineering by Capote and Mandawe
3. Refresher Manual by JAS Tordillo